- - 102.(Amended) A method in accordance with claim 101 above, wherein the interleaver generates two beam pairs, to be differentially delayed, the beams of each pair being displaced from each other but also paired individually with a different beam from the other pair, wherein the method further comprises the step of separately adjusting the angles of the polarization vectors for the individually paired beams from the two different beam pairs.

- - 107. (Amended) A waveplate combination as set forth in claim 106 above, wherein the optical beams generating differential retardance comprise four parallel beams in quadrants arranged as two pairs, each with orthogonal polarizations.

- - 109. (Amended) An interleaver optical filter component dividing an input multi-wavelength beam into interleaved multiple even channels and multiple odd channels and including separate retardation stages, the filter component including polarization rotators between stages and the polarization rotators being configured to provide beam angles into the retardation stages such that the desired optical transmission response is synthesized.

- - 113.(Amended) An interleaving optical filter in accordance with claim 109 wherein the retardation stages consist of synthetic birefringent elements utilizing two glass delay line elements, wherein the glass elements are of nominally equal lengths and exhibit compensating temperature dependencies such that the optical frequency periodicity of the interleaver drifts by less than ±1.5 GHz over the operating temperature range of 9 to 70°C.- -

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<u>REMARKS</u>

<u>RESPONSE TO RESTRICTION REQUIREMENT</u>

After reviewing the claims, a number of amendments for the purpose of correction informalities, principally as to numbering, have been made. No new matter is involved. The added phrase in claim 109 simply provides an antecedent for following claim language and is inherent in the context of the claim. Marked up copies of the amended paragraphs and claims are attached.

Applicants respectfully traverse the Restriction Requirement and request reconsideration on the grounds that the requirement as set out in the Office Action is merely conclusory, gives no reasons for the holding that there are 14 species, and fails to "clearly identify each ... of the disclosed species, *to which claims are restricted*" (MPEP 809.02(a), emphasis in original). This request is <u>not</u> made on the basis that all 113 claims should be considered together, because a substantial number of claims will be excluded, as noted hereafter in the provisional election. The reconsideration request is instead based upon the fact that the 14 enunciated "patentably distinct species" provide no discernible basis for election. Instead, the restriction requirement merely makes abbreviated or short-hand reference to functional factors affecting the design or operation of filter systems in accordance with the invention. The 14 "species" do not pertain to <u>claimed</u> combinations or methods, and do not acknowledge that some of the claims (e.g. 100-113) are directed to different subcombinations which properly present steps, elements or operative relationships that are more specifically focused. Tuning, quadratic group delay adjustment, compensating for chromatic dispersion and compensating for polarization mode dispersion are important aspects of these subcombination claims, but the functional results of these individual elements do not stand alone as patentable concepts. Attention is called to the fact, for example, that if claim 113 is studied in relation to the "species" characterized in the Office Action, it will be seen that it incorporates a number of the "manipulations" or "compensations" set out in the Office Action. This demonstrates that the interrelationships in this technology are so interwoven that they cannot be extracted in the manner chosen by the Patent Office action.

The claims have been carefully reviewed in an effort to understand how "manipulation" (a term used in the Office Action but not employed in the claims) of different operative parameters or states can be construed to serve as a basis for election, or for searching, or for claim analysis relative to the prior art. Applicants must confess that no such basis can be found and it is respectfully submitted that the arbitrary categorizations of interrelationships or results set out in the Office Action do not correspond to accepted practice as regards restriction requirements. Therefore it is respectfully submitted that applicant's provisional grouping and election of systems apparatus claims, as set out below, should be accepted, or

that a new analysis should be made of the subject matter, in conventional terms and consistent with established practice.

Applicants hereby provisionally elect, in response to the Requirement for Restriction, the group of claims exemplified by systems and apparatus claims 1-70. The claims in this group define combinations characterized by the use of optical delay lines formed by the use of non-birefringent or polarization insensitive elements, to provide differential optical paths for input signals, typically wavelength division multiplexed, which are split or divided into different polarized components, wavelength dependent filtered (e.g. interleaved or de-interleaved) before recombination by polarization responsive elements. Applicants respectfully submit that, when the independent claims 1, 24, 34, 42, 48, 58, 65 and 71 in this grouping are carefully analyzed, they will be seen appropriately to fall within the same subject matter in the classification system, whatever that might be (since it was not specified in this Office Action). Furthermore, it will be recognized that the sequences of dependent claims following after each of the parent claims comprise further distinguishing features and that with the claims as written, none of the elected claims seek coverage of individual tuning, correction or compensating features. Applicants also submit that in view of the technical contributions disclosed in the application, they are entitled to claims of the scope and variety of claims 1-70.

The considerable number of claims elected are testimony to the complexity of this technology and the numerous new expedients the inventors have employed in bring the claim system to realization. By the present provisional election, however, method claims 71-99 and subcombination claims 100-113 are proposed for withdrawal and the analysis problem is thereby simplified.

It is submitted, in summary, that the elected claims will properly be congregated within that section of the optical filtering art which includes interleavers and other wavelength dependent systems, even though different expressions and verbalizations have been used. For example, independent claims 1 and 24 do not specify the interleaver function but reference the problem of modifying transmission characteristics of an input optical signal in accordance with wavelength, using polarization, splitting, optical delays of known birefringent elements and

beam recombining. Claim 34 expresses the filtering function with greater economy of language, but characterizes the functions in terms which are intellectually comparable. Claim 42 to a "system for introducing a periodic transmissive function to an input output optical beam" is parallel in a general sense to claim 34. Independent claim 48 to a "multistage optical signal interleaver" incorporates the same distinguishing elements and relationships in the interleaver context, and the fact that individually patentable stages are used in combination does not introduce the need for searching substantially different art. Parent claim 58 to a "compact interleaving filter component" incorporates related basic elements and relationships with variants in emphasis. Parent claim 65 is also to a "multistage optical signal interleaver" with features for demultiplexing DWDM channels being emphasized.

In the light of the above considerations, applicants respectfully request substantive analysis of this application based upon the provisional election of the group of claims identified herein, namely claims 1-70. Alternatively, applicants request that the original Requirement for Restriction be supplanted by a new requirement on the basis of which the logic of claim segregation can be identified and claim selection can be made.

Respectfully submitted,

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grid, the ½ waveplates 43 and 44 are individually rotated in transverse grooves 48 in the bench 12, typically using an optical spectrum analyzer to measure the interleaver response before fixing the waveplates in place. Separate adjustments within as much as a 45° range vary the frequency response of the upper and lower beam pairs, respectively, to coincide with the ITU grid to within 1 GHz or 2p/100 radians. The lengths of the glass delay elements are precisely controlled to give a frequency period of 100.00 ±0.01 GHz or, in general, a period equal to twice that of the input channel spacing.

[0044] As seen in the perspective of Fig. 4 and schematic of Fig. 5, in the second waveplate combination 40 each different waveplate 42-45 is mounted in a flat or planar short central body 49 that fits into the associated transverse groove 48 holder on the optical bench 12. Side wings 51, 52 enable easy rotational manipulation of the waveplate angle. The active optical element, e.g. the ¼ or ¾ waveplate 42, is set into a central aperture 54 in the body 49. In this instance the first ¾ waveplate, as seen in Fig. 5, converts the linear polarizations of the input beams to circularly polarized beams of opposite senses so that the right beams have positive directions of circulation and the left beams have negative directions of circulation (Fig. 3). The states of polarization of the upper and lower beam pairs are then selectively and separately transformed by the ½ waveplates ~~42~~ 43, ~~43~~ 44 which respectively span the upper beams only and the lower beams only. Separate transformation is necessary because the practical limitations on parallelism dictate that the upper and lower beams be separately phase tuned. The open parts of the apertures 54 in these ½ waveplates ~~42, 43~~ 43, 44 permit unoccluded passage of the unaffected upper or lower beam pair. The last waveplate in the second

[0079] This unique ability to achieve control of chromatic dispersion enables a matched mux/demux interleaver pair to be produced which produces zero net chromatic dispersion, as shown generally in Fig. 14. Alternately, for some applications multiplexing is performed with a 50/50 splitter rather than an interleaver. In this case, zero CD can be achieved if multiple demultiplexers are used in a single link, as in add/drop applications, for example, by suitable pairing. This is effected by configuring demultiplexers as pairs with dispersion of compensating signs. Note that an interleaver does not need to be configured as a multiplexer to compensate for the CD of a demultiplexer; in fact, the bi-directional nature of these interleavers enables any one component to function as both a multiplexer or demultiplexer.

[0080] The tunable, chromatic dispersion compensator is based on cascading two suitably configured interleavers in series. The group delay of an interleaver can be either quadratic up or quadratic down, depending on whether the ordinary or extraordinary polarization is used as the input to the filtering stages, or depending on the relative phases between the individual time delay stages. The approximately quadratic group delay produces an approximately linear dispersion characteristic within the channel passband. Two cascaded interleavers may thus be arranged to cancel out the dispersion slope and provide a constant dispersion, as shown schematically in Fig. 14. The amount of dispersion can be tuned by introducing a wavelength shift ~~of~~ at the first interleaver relative to the second interleaver. The shift can be produced by tuning the absolute frequency of the interleaver. The passband must be sufficiently low loss within the desired tuning range. For example, a pair of modified 50 GHz interleavers will enable a fixed amount of dispersion to be produced at all channels on a 100 GHz grid passing through the

38. A microoptic element as set forth in claim 37 above, wherein the signal delay paths comprise several stages each having at least one glass element, the first stage elements having a length L and disposed in a series of n elements, where n is an integer of 1 or greater, and succeeding stages having total lengths that are integer multiples of nL in length.

39. A microoptic element as set forth in claim 38 above, wherein the stages each include different glass elements selected to provide a passive athermal characteristic over a selected temperature range in each stage.

40. A microoptic element as set forth in claim 39 above, wherein the stages further include waveplate tuning elements for adjusting the periodicities of the outputs precisely to the ITU grid and the glass elements are 8-16 mm in length and the microoptic element is less than about 15 cm in total length.

41. A microoptic element as set forth in claim 40 above, wherein the output beam splitter comprises a first output beam splitter oriented to split each optical signal into two orthogonally polarized beams and a second output beam splitter orthogonally positioned relative to the first output beam splitter to recombine optical beam sets to polarization insensitive outputs.

42. A system for introducing a periodic transmissive function to an input optical beam of an arbitrary state of polarization having wavelength multiplexed channels comprising:

at least a first beam splitter arrangement receiving the optical beam and providing two beam pairs of different polarizations;

a pair of polarization insensitive optical delay lines, each in the path of a different beam, and introducing selected differential optical delays between beam pairs to provide wavelength dependent, polarization modulated beams carrying the multiplexed channels; and

at least a second beam splitter arrangement receiving the different beams from the delay lines and combining them to form ~~a~~ wavelength dependent, polarization modulated beams which transmit multiplexed channels of different spacings than the input.

43. A system as set forth in claim 42 above, wherein the optical delay lines comprise non-birefringent elements of substantially like physical lengths and different indices of refraction.

44. A system as set forth in claim 42 above, wherein the optical delay lines in the different paths are glass elements selected to have like optical path length changes with temperature.

45. A system as set forth in claim 44 above, wherein the glass elements are of lengths and refractive indices selected to compensate for thermal expansion and thermooptic effects along the two beam paths.

46. A system as set forth in claim 42 above, wherein the optical delay lines are arranged in at least two stages with integer related optical delay differential characteristics whose total differential optical lengths vary by integral multiples such that transmission passbands are shaped to selected characteristics.

47. A system as set forth in claim 42 above, wherein the system comprises in addition at least one additional stage of a pair of polarization insensitive optical delay lines in series with the first pair, input polarization management optics associated with the first

66. An interleaver as set forth in claim 65 above, wherein each stage includes polarization beam splitter means arranged to direct at least two beam pairs through the stages, and each beam delay path includes a waveplate combination for phase tuning to selected channel placements.

67. An interleaver as set forth in claim 66 above, wherein the non-birefringent optical elements comprise glass elements substantially of basic length L, and wherein channel spacing is defined by serial disposition in the stages of integer multiples of elements of the basic length and frequency period is adjusted by angling at least on polarization beam splitter.

68. An interleaver as set forth in claim ~~64~~ 65 above, wherein the stages comprise three stages of total lengths L, 2L and 2L for a 50 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

69. An interleaver as set forth in claim ~~64~~ 65 above, wherein the stages comprise two stages of nominal total lengths 2L and 4L for a 25 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

70. An interleaver as set forth in claim ~~64~~ 65 above, wherein the stages comprise two stages of nominal total lengths 4L and 8L for a 12.5 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

71. A method of providing an interleaved optical frequency response for filtering WDM channels carried by a polarized or unpolarized optical beam comprising the steps of:

splitting the input beam into linearly and orthogonally polarized beams spaced apart in a first direction;

deriving intensity modulated output signals having frequency dependent transmission characteristics.

97. The method as set forth in claim 96 above, further including the step of repeating at least once the sequence of steps including the splitting of beams, applying different retardation delays, and introducing different phase tuning.

98. The method as set forth in claim ~~95~~ 96 above, wherein the step of phase tuning is performed in association with the application of differential delays.

99. The method as set forth in claim ~~95~~ 96 above, wherein the step of phase tuning is performed independently of the application of differential delays.

100. In an optical signal interleaver employing at least one birefringent polarization beam splitter and at least one differential delay stage for providing, by interferometric operation, transmittance passbands centered on frequencies in an ITU grid, the method comprising the steps of:

directing an optical beam having multiple frequency components through the at least one polarization beam splitter into the differential delay stage, and

varying the angle of the beam relative to the at least one polarization beam splitter to adjust the frequency period of the transmittance passbands derived from the at least one stage.

101. In an optical signal interleaver in which differential delays in optical elements are employed to derive, from wavelength division multiplexed input signals, output signals in a different multiplexed format that have frequencies aligned with standards in an ITU grid, the method comprising the steps of:

in association with the optical elements, providing at least two beam components subject to the differential delay;

generating circular stages of polarization in the at least two beam components, and

separately adjusting the polarization vectors of the at least two beam components to vary the phases of the beams such that the output signals match the frequencies of the ITU grid.

102. A method in accordance with claim ~~100~~ 101 above, wherein the interleaver generates two beam pairs, to be differentially delayed, the beams of each pair being displaced from each other but also paired individually with a different beam ~~form~~ from the other pair, wherein the method further comprises the step of separately adjusting the angles of the polarization vectors for the individually paired beams from the two different beam pairs.

103. An interleaver device for optical signal communications, comprising:

a planar surface bench structure having an array of mounting pads disposed along a longitudinal axis along the plane of the surface;

at least two differential retardation stages in series and each comprising glass elements mounted on the pads along the longitudinal axis, the glass elements being elongated rectangular elements with their axis of elongation parallel to the longitudinal axis, the glass elements of each stage being arranged in side by side relation to provide two separate beam paths for differential retardation, with close longitudinal abutment of glass elements serially disposed in any individual stage;

at least one waveplate combination disposed between each successive pair

generating differential retardance for first and second pairs of optical beams of orthogonal polarization comprising:

a first quarter waveplate oriented at plus or minus 45° to the polarization axis of the optical beams;

a first half waveplate disposed in the paths of the first two optical beams and adjacent the quarter waveplate, and rotatable with respect to the polarization axis to adjust the absolute frequencies of the interleaver transmission peaks to match the target peaks;

a second half waveplate disposed in the paths of the remaining two optical beams and adjacent the quarter waveplate and rotatable with respect to the polarization axis to adjust the absolute frequencies of the interleaver transmission peaks to match the target peaks; and

a second quarter waveplate oriented at minus 90° to the first quarter waveplate to convert the first and second pairs of optical beams to linear states of polarization.

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107. A waveplate combination as set forth in claim 1~~02~~ above, wherein the optical beams generating differential retardance comprise four parallel beams in quadrants arranged as two pairs, each with orthogonal polarizations.

108. A waveplate combination as set forth in claim 107 above, wherein the first quarter waveplate converts the orthogonally polarized beams to circular states of polarization.

109. An interleaver optical filter component dividing an input multi-wavelength beam into interleaved multiple even channels and multiple odd channels and including

the filter component including polarization rotators between sta

separate retardation stages, the polarization rotators being configured to provide beam and

angles into the retardation stages such that the desired optical transmission response is synthesized.

110. An interleaver optical filter component in accordance with claim 109 above, wherein the polarization rotators comprise input waveplates arranged to rotate the polarizations of both beams to selected angles before entering the filtering stages such that even channels exhibit approximately quadratic group delay characteristics of opposite sign to the odd channels.

111. An interleaver optical filter component in accordance with claim 109 above wherein the retardation stages exhibit relative phases configured such that the even channels exhibit approximately quadratic group delay characteristics of opposite sign to the odd channels.

112. An interleaving optical filter arrangement in accordance with claim 109 wherein a compensating pair of interleaver optical filter components are disposed in the channels and configured to operate in series combination to provide zero chromatic dispersion in transmission through the pair.

113. An interleaving optical filter in accordance with claim ~~97~~ 109 wherein the ~~filtering~~ retardation stages consist of synthetic birefringent elements utilizing two glass delay line elements, wherein the glass elements are of nominally equal lengths and exhibit compensating temperature dependencies such that the optical frequency periodicity of the interleaver drifts by less than +/-1.5 GHz over the operating temperature range of 0 to 70°C.